

such as might be anticipated. As an illustration of this I will take the Californian earthquake of April 18. This originated along lines of great length on the western side of that country. The reflecting surface I take to be the Sierras, 200 miles distant. A wave group would travel to the Sierras and back in about four minutes, and this is approximately the time interval between the two first large wave groups in the few seismograms I have of that disturbance.

In offering these suggestions I concur with Dr. Farr that very frequently terminal vibrations of an earthquake present characteristics suggestive of interference effects, but it is premature to suppose that all the peculiarities of a seismogram are to be explained in the same manner. Rhythmical beats at an origin may result in rhythmical beats at a distance.

JOHN MILNE.

Shide, Isle of Wight, September 5.

### Remarkable Rainbow Phenomena.

On Monday, September 3, a very heavy thunder-shower passed from west to east over the parish of Deerness, Orkney, from 5.30 p.m. to 6.25 p.m. When the dark nimbus cloud to the west had lifted its pall, the sun came out in great brilliancy. A rainbow now began to form to the north-east, but instead of the ordinary bow there was one of a bifurcated nature. Two stumps which coalesced on the horizon gradually developed into two magnificent bows, which met on both horizons, viz. north-east and south-west, but were about five or six degrees apart at the apex. All the colours of a radiant bow were present in both, and both had the colours arranged in the order of the primary bow. The secondary bow also appeared with the colours reversed and the same bifurcation, but in this case it extended only to about thirty or thirty-five degrees above the horizon, as secondaries generally do. As I had never seen or heard of anything like this, my first impulse was to find a cause. When the double rainbows were at their best, there was a bar of stratus cloud extending across the middle of the sun, and in breadth about one-sixth of its diameter. The two primary bows remained complete from 6.30 p.m. to 6.35 p.m., and without the arc of the apex for about another five minutes.

At first the bow to the south was the more complete, and finally the one to the north. However, after the sun had crept from behind the bar of cloud there were still double stumps clearly visible. If the cause here attributed be correct, then the only explanation of the bifurcated rainbow being visible after the cloud passed is, that from the points of the heavens where the rainbows were the bar might still be dividing the sun's rays. Nothing in my meteorological books indicated that this phenomenon had been previously seen. On inquiring as to what others had seen after the thunder-shower, two friends, one five miles and the other three miles almost directly west of me, saw only a perfect bow and its secondary. Others nearer the position I occupied saw what they called four rainbows, but had observed neither the coloration nor bifurcation clearly enough for descriptive purposes.

M. SPENCE.

Deerness, Orkney.

### The Mixed Transformation of Lagrange's Equations.

MR. A. B. BASSET, in a letter to NATURE of August 2, states that the theory of the mixed transformation was first given by himself in 1887, and refers to his treatise on "Hydrodynamics," vol. i., p. 171. If he will kindly look at my essay for the Adam's prize, pp. 61-4, he will find an elimination similar to that which he speaks of. The resulting modified functions appear to agree term for term. There is also the introduction of a "modified function" by which we can use Lagrange's equations for some of the coordinates and Hamilton's equations for the others. That essay dates from December, 1876, and was published in August, 1877. The method was afterwards explained without much change in all the editions of my "Rigid Dynamics" which follow that date, beginning with the fourth edition, 1882.

E. J. ROUTH.

September 14.

NO. 1925, VOL. 74]

### THE RECENT CONTROVERSY ON RADIUM.

THE recent correspondence on the subject of radium, started in the *Times* by Lord Kelvin, has, after lasting nearly a month and causing widespread interest, apparently closed without any very definite conclusion being reached. Whatever opinion may be formed of the merits of the controversy, all must unite in admiration for the boldness with which Lord Kelvin initiated his campaign, and the intellectual keenness with which he conducted, almost single-handed, what appeared to many from the first almost a forlorn hope against the transmutational and evolutionary doctrines framed to account for the properties of radium. The weight of years and the almost unanimous opinion of his younger colleagues against him have not deterred him from leading a lost cause, if not to a victorious termination, at least to one from which no one will grudge him the honours of war. If peace and tranquillity now result, and a measure of agreement is arrived at between conflicting views, it will be a result which all concerned will heartily welcome. The most ardent believer in the truth of the new doctrines cannot be other than satisfied that every feature and assumption that is admittedly speculative should be clearly recognised as such and separated from that which is not, if thereby the experimental foundations of the science of radio-activity are freed from further wordy and unprofitable controversy. There seems now to be a reasonable prospect that this has been secured.

Lord Kelvin's opening challenge (August 9) was broad and sweeping. He took exception to the statement, made by the writer in opening the discussion on the evolution of the elements at the British Association at York, that the production of helium from radium has established the fact of the gradual evolution of one element into others, and denied that this discovery affected the atomic doctrine any more than the original discovery of helium in cleveite. The obvious conclusion was that both cleveite and radium contained helium. He also stated that there was no experimental foundation for the hypothesis that the heat of the sun was due to radium, and ascribed it to gravitation.

The challenge was taken up on the other side successively by Sir Oliver Lodge, the Hon. Mr. Strutt, and other well-known authorities, and it soon became apparent that for argument at least Lord Kelvin on his side had to rely practically on himself alone. Prof. Armstrong, it is true, immediately enrolled under Lord Kelvin's banner, and entered the lists with an embracing criticism of physicists in general, whom, he declared, are strangely innocent workers under the all-potent influence of formula and fashion. He made the statement that no one had handled radium in such quantity or in such manner that we can say precisely what it is, and throughout put the word *radium* in inverted commas.

Whether or no his opponents are all as innocent and ignorant as Prof. Armstrong imagines, the fact remains that, except for this *ex cathedra* utterance and a leading article, argument against the accepted view there was little or none except that contributed by Lord Kelvin himself. Prof. Armstrong's letter merely served to provide Sir Oliver Lodge with justification for his favourite theme, which appears to be that whereas chemists have an instinct of their own for arriving at their results, reason is the monopoly of the physicist, whose results the chemist usually manages to absorb in the end. No better argument against the unfairness of this could be provided than by the history of radio-activity itself, which

owes at least as much to the chemist as to the physicist. Prof. Armstrong is almost alone among chemists, as Lord Kelvin is among physicists, in his hostility to the new doctrines.

Mr. Strutt in two letters (August 9 and 21) asked what became of the heat generated by the radium admitted to be present in the earth, and recalled the independent evidence of several workers of the continuous renewal of helium from radium. Sir Oliver Lodge directed attention to the magnetic deflection of the  $\alpha$ -particle as evidence that material particles are expelled from radium, and in his letter laid perhaps undue weight on the evidence, which is still far from complete, that the  $\alpha$ -particle is an atom of helium. The vagueness of this argument, and the fact that the letter raised a doubt whether Lord Kelvin had sufficiently examined the published evidence, a doubt which Lord Kelvin himself promptly dispelled, was the subject of a leading article in the *Times* of August 18. The writer of that article attacked the evidence for the production of helium from radium, using some well-known arguments. The minute quantity of emanation was graphically likened to a bubble rising through a glass of whiskey and soda, and it was held that the results were vitiated by the well-known changes the spectra of gases undergo under the prolonged action of the current, due to occlusion by the electrodes and selective conduction rather than to any transmutation. It may be here remarked that the same arguments were set forth in full by Himstedt and Meyer as a preliminary to their experimental examination of the question, yet Himstedt and Meyer, as the result of their own experiments, were finally forced to the conclusion that helium is in fact produced from radium.

Lord Kelvin in his replies (August 20 and 24) made it clear that he accepted as a fact the continuous evolution of helium from radium, and this admission narrowed very much the issue involved. In reply to a statement of Strutt that if all the helium is removed from radium after an interval a further supply can be extracted, Lord Kelvin remarked simply that the *if* of the statement was wrong. This point was dealt with by the present writer (August 31), who considered the argument could be definitely answered. For helium is produced from the emanation of radium, about which no question of its being really reproduced can exist. For the removal of the emanation is marked by changes in the radio-activity, notably by the  $\beta$  rays, which vanish when the emanation is removed. The recovery of the radio-activity occurs at a definite rate, and is concomitant to the reproduction of emanation, which can at any time be again extracted as before. As there is no question of the radium creating helium, the only point open for argument is the exact character of the decomposition by which it and the emanation which gives rise to it are formed. As there was no further reply to this criticism, it may be taken that the main point of the disintegration theory, that there is a continuous change in the radio-active matter accompanying the radio-activity, is unanswerable.

On the important question as to the character of the decomposition by which the helium is formed, Lord Kelvin in his later letters favoured a view very different from that of mere occlusion, which the original analogy to cleveite suggested. He quoted a statement of Prof. Rutherford in favour of regarding radium as a chemical compound of helium and other elements, and suggested that radium might be made up of one atom of (?) lead and four of helium. In a final letter (September 4) Sir Oliver Lodge pointed out that this was the key of the position. Is radium

a compound or an element? It is satisfactory that, after so much fencing with the question, so simple an alternative has been arrived at. Perhaps the most significant thing about the view that radium is a compound is the silence of the chemists. Surely a chemist might fairly be supposed to know whether a change is what is called a chemical change or not, and the fact that it has been left to a physicist to adopt this view seems fair comment. Not even Prof. Armstrong has yet accepted it.

On the second point of his challenge, the denial that the heat of the earth is due to radium, Lord Kelvin naturally had an easier task, for matters connected with the interior of the earth must necessarily remain speculative. If radium did not decompose under the conditions prevailing in the interior it would emit no heat, and would not tend to diminish in quantity, accounting perhaps, although with some difficulty in view of the wide distribution of radium in surface rocks, for the continued existence of the substance at the present time. Mr. A. S. Eve, in a vigorous letter (August 28), stated that he had confirmed the estimate of Mr. Strutt of the amount of radium in the earth's crust by a new method, in which the penetrating radiation from the earth's surface was used as the basis of measurement. Although, of course, in view of the evidence of the independence of radio-active changes upon their environment, it is more of an assumption to suppose that in the interior of the earth radium does not decompose than to take the opposite view, yet clearly here, at any rate, there is plenty of room for legitimate differences of opinion. On the other hand, even the opponents of Mr. Strutt's view cannot deny the potentialities of radio-activity, and the part it might play in cosmical processes under favourable conditions.

The theory that radium is a compound, waiving the qualification *chemical*, will no doubt serve sufficiently well for the present as a point of common agreement. As Sir Oliver Lodge remarked, there is no necessity that the question be settled offhand. As a stepping-stone to further conclusions, it offers advantages to the conservative and cautious. It expresses a bare minimum of established fact which even the most sceptical are unable to invalidate. This minimum, briefly stated, is that radium is undergoing a continuous change intimately connected with its radio-activity, and that in this change helium is produced, and an enormous but definite amount of energy liberated. Whether anything more is known about transmutation now than formerly, whether lead could change into gold or gold into silver with an emission of energy similar to that evolved from radium, whether this or similar energy plays the large share that has been attributed to it in cosmical processes, are questions which may be legitimately discussed and left open, if only for the reason that they are far from decided. They are all admittedly steps into the region of hypothesis.

But what a miserable fraction, even of the known facts, this minimum is! Ostensibly an explanation of radio-activity, it begins and ends with the fact of the gradual evolution of helium from radium. The numerous other products of radium, the volatile emanation and its non-volatile products, known by their characteristic radio-activity, much as minute quantities of ordinary gases and solids are known by their characteristic spectra, the slower changing later products, of which polonium is one, and is chemically as reminiscent of tellurium as its parent is of barium, remain still to be systematically accounted for. On the important subject of the nature of the  $\alpha$ ,  $\beta$ , and  $\gamma$  rays, and their origin, the view is silent! The fact

is ignored that radio-activity is, to use Mme. Curie's happy expression, an atomic property, that is, is independent of the particular state of chemical combination of the radio-element. Radium resembles in the closest possible manner barium, a completely inactive element in the same family of the periodic table, both in chemical nature and in the series relationships of its spectrum. Barium is an element, radium is a compound; but whether uranium and thorium are elements or compounds is undecided. Again, the emission of energy, greater a million-fold than that evolved in any previous material change, remains a mystery in company with the discrepancy between the physical and geological estimates of the age of the earth. The constancy of ratio between the quantities of radium and uranium in all natural minerals is another experimental fact unexplained.

It is the glory of the accepted view that it harmonises and correlates all the preceding problems, offering a simple and unstrained physical explanation of each, capable of being tested by quantitative experiment. In addition, it reaches out in every direction in broad, bold predictions, a few of which, like the production of helium from radium and the constancy of ratio between uranium and radium in minerals, have been brilliantly confirmed by experiment, while the majority simply await more refined experimental methods of attack. Of what other theory could the remark be made, which is attributed to Prof. Rutherford, that when a single experimental fact is established which does not conform to the disintegration theory it will be time to abandon it? The theory would have to be fundamental indeed to pass this test.

The secret of the vague hostility to the new doctrines which the recent controversy has shown to be widely felt is to be found probably in the impossibility of forming from words or reading the least idea of the really startling character of some of the new discoveries. This is particularly true of perhaps the most wonderful of them all, the radium emanation. Even Lord Kelvin in one of his letters speaks vaguely of emanations, while Sir William Crookes, at least until quite recently, employed the word, also in the plural, as a generic term for the *radiations*. Give a scientific man a few milligrams of radium in solution and ask him to perform for himself some of the stock experiments with the emanation, for example, its condensation by liquid air, the concentration on the negative electrode of the active deposit formed by it, the steady decay of its powers after removal from the radium, and the growth of new emanation from the radium, kept, let us say, in another building or another country; then the radium emanation passes from being a phrase to a fact which no theory can safely ignore. The same is equally true of thorium X, radium C, and the numerous other successive products of radio-active change.

It would be a pity if the public were misled into supposing that those who have not worked with radio-active bodies are as entitled to as weighty an opinion as those who have. The latter are talking of facts they know, the former frequently of terms they have read of. If, as a result of the recent controversy, it has been made clear that atomic disintegration is based on experimental evidence, which even its most hostile opponents are unable to shake or explain in any other way, the best ends of science will have been served. The sooner this is understood the better, for in radio-activity we have but a foretaste of a fountain of new knowledge, destined to overflow the boundaries of science and to impregnate with teeming thought many a high and arid plateau of philosophy.

F. SODDY.

## THE MYSTERIES OF LHASA.<sup>1</sup>

THIS is a new and cheaper edition of Colonel Waddell's account of our recent expedition into Tibet. In its more expensive shape it passed through two editions, and the present one is a marvel of cheapness. Not very many of the illustrations in the issue of last year are omitted in this year's reprint, and the type is the same, so much so, indeed, that it has not been considered necessary to remove from the letterpress references to photographs that have not been reproduced (see, for instance, pp. 369, 374, 406, and 411). It is not often that one can buy a handsomely printed book of 550 pages, with more than 150 illustrations, eight excellent maps and plans, and a very good index for a few shillings.

One of the most alluring things about the book is its title. The contents bear out this title only to a limited extent. It is true that we have here a description of Lhasa and its sights of much the same kind as a guide-book would give of a European city and its sights; but not much of this is very new. We have had descriptions, and even photographs, of Lhasa and its palaces before. What people mean when they speak of the mysteries of the place may include this, but it refers in the main to something very different. The author is well aware of this. He refers in his preface to the curiosity stimulated by the belief that somewhere behind the mighty Kanchenjunga there would be found a key to unlock the mysteries of the world; and the belief in the possibility of this is widely diffused.

The ball was set rolling, though this is not generally known, by the famous Earl of Chesterfield, the author of the well-known letters to his son. This was done in another work of his entitled "The Economy of Human Life," published in 1751. Unwilling at that date to give his views of life and religion under his own name, he wrote anonymously; and the method he adopted was to prefix to his book an elaborate introduction, in which he describes Lhasa, its palaces and its libraries, tells us how the Emperor of China, fully convinced that there could be found in those libraries ancient books of wisdom, sent a learned minister, "of a grave and noble aspect," and armed with an autograph letter from the Emperor to the Grand Lama, to discover them; tells us further how the minister found many "curious pieces of antiquity," and how the most ancient of them all was precisely the original of this "Economy of Human Life"; and finally explains the very curious ways in which this ancient MS. was translated, and then sent to him, who now gives it to the world. It is all very well done—as romance; but it was taken in sober earnest. The book went through more than fifty editions, and has been often translated. No one seems to have divined, until last year, that it was merely an English book of the eighteenth century. The editor of the last English edition (1902) still speaks of it as "this ancient wisdom"; and its great success led to no less famous imitations purporting to be the work of the so-called Mahatmas of Tibet. On these interesting delusions the author merely states that inquiries of learned Tibetans he happened to meet with, and such cursory examination as was possible of the libraries passed on the road, led to no result. Such negative evidence is not of much value. He might have added that the mystery is not in Tibet at all, but in certain phases of European thought.

In this connection it is noteworthy that Colonel

<sup>1</sup> "Lhasa and its Mysteries, with a Record of the Expedition of 1903-4." By L. A. Waddell, LL.D., C.B., Lieut.-Col. Indian Medical Service. Third Edition. Pp. xx+539. (London: Methuen and Co., 1906.) Price 7s. 6d. net.